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PATENT SPECIFICATION 903,959

NO DRAWINGS.

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Date of filing Complete Specification : March 7, 1961.

Application Date : April 1, 1960. No. 11702/60.

Complete Specification Published : Aug. 22, 1962.

Index at Acceptance :—Class 6(2), E5A.

International Classification :—A01g.

COMPLETE SPECIFICATION.

Improvements relating to the Treatment of Granular Soils.

We, SOIL MECHANICS LIMITED, a British Company, of 65 Old Church Street, London, S.W.3, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

In the construction of civil engineering works, for example tunnels and deep foundations, it is sometimes necessary to reduce the permeability to water of water-bearing granular soils such as sand to stop or reduce the flow of water through it.

According to the present invention, a method of reducing the permeability to water of granular soils comprises injecting into the soil an aqueous solution containing a soluble salt of alginic acid and an ester and allowing the ester to hydrolyse and the solution to form a gel in the interstices of the soil.

The gel is formed by the reaction of the alginate with acid formed by the hydrolysis of the ester so that alginic acid which is an insoluble gel is produced.

The preferred salt of alginic acid is a sodium salt.

The ester may be ethyl acetate and in this case the ethyl acetate is hydrolysed to ethanol and acetic acid and the acetic acid liberates alginic acid from the alginate.

The gel may additionally be formed by the reaction of the soluble alginate with calcium or magnesium salts to form insoluble calcium or magnesium alginate both of which are also gels. The calcium or magnesium salts may occur naturally in the soil, the carbonates being the most usual, or a soluble salt of calcium or magnesium, for example calcium chloride, may be added to the solution before injection. When the soil contains for example calcium carbonate there is the advantage that the addition of an ester and a soluble calcium or magnesium salt to the solution to be injected is not necessary. On the other hand if the injected solution does contain these two additives, the gel is formed more quickly and is dispersed more evenly throughout the soil. However if these two additives are used, the two processes for producing calcium, or magnesium alginate or both in the ground are very often concurrent as most soils contain calcium or magnesium, usually as the carbonate.

A solution containing as little as 0.1 per cent by weight of sodium alginate is effective but for the most satisfactory results the solution should contain 0.5 per cent of the substance by weight or even more if the soil is initially particularly permeable.

Because of the small proportion of the alginate necessary in the solution this method of reducing the permeability of soils is cheap but more important is that the solution has a low viscosity, since it has a consistency similar to that of milk and it is therefore easy to inject into the soil.

The solution may be injected through an injection pipe by means of a pump similar to that commonly used for injecting cement grout or solutions previously used for chemical consolidation of soils.

EXAMPLE I.

A laboratory experiment was carried out using Ham River sand with its natural degree of compaction and having initially a permeability coefficient of 5×10^{-2} cms/sec. A grout, which consisted of a 1% aqueous solution of sodium alginate containing 10 ml. of 1% by weight of calcium chloride solution

[*Price 4s. 6d.*]

per 100 grams of liquid and 1% ethyl acetate was injected into the sand. The ethyl acetate was hydrolysed to ethanol and acetic acid and the acetic acid liberated alginic acid from the sodium alginate. The alginic acid then reacted with the calcium ions from the calcium chloride solution to form insoluble gel of calcium alginate. The resulting permeability coefficient of the sand was found to be 2.9×10^{-6} cms/sec. As a result of the experiment, the permeability coefficient of the sand was therefore reduced by a factor of approximately two million.

EXAMPLE II.

A second laboratory experiment was carried out on another sample of Ham River sand. A grout which consisted of a 1% by weight of aqueous solution of sodium alginate containing 1% ethyl acetate was injected into the sand. As in the first example, the ethyl acetate was hydrolysed and the acetic acid thus formed released alginic acid from the sodium alginate. The alginic acid gelled in the interstices of the sand and reduced the sand's permeability to water, although not as efficiently as the calcium alginate in the first example.

WHAT WE CLAIM IS :—

1. A method of reducing the permeability to water of granular soils comprising injecting into the soil an aqueous solution containing a salt of alginic acid and an ester and allowing the ester to hydrolyse and the solution to form a gel in the interstices of the soil.

2. A method according to Claim 1, in which the salt of alginic acid is a sodium salt.

3. A method according to Claim 2, in which the solution contains at least 0.5% by weight of sodium alginate.

4. A method according to any one of Claims 1 to 3, in which calcium or magnesium ions are present when the gel is formed and the gel includes calcium or magnesium alginate.

5. A method according to any one of the preceding claims in which the ester is ethyl acetate.

6. A method according to Claim 4 or to Claim 4 and any one of the other preceding claims, in which the solution contains an inorganic calcium of magnesium salt.

7. A method according to Claim 6, in which the solution contains 10 mls. of 1% by weight of calcium chloride solution per 100 grams solution of the salt of alginic acid.

8. A method according to Claim 1, substantially as described with reference to any one of the examples.

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PROVISIONAL SPECIFICATION.

Improvements relating to the Treatment of Granular Soils.

We, SOIL MECHANICS LIMITED, a British Company, of 65 Old Church Street, London, S.W.3, do hereby declare this invention to be described in the following statement :—

In the construction of civil engineering works, for example tunnels and deep foundations, it is sometimes necessary to reduce the permeability to water of water bearing granular soils such as sand to stop or reduce the flow of water through it.

It has now been discovered that this can be done very effectively and cheaply in the case of granular soils containing a carbonate by injecting into the soil a solution in water of a polysaccharide containing free carboxylic acid groups or a salt thereof.

The polysaccharide reacts with the carbonate to form a highly water insoluble gel which is deposited in the interstices of the soil. In most soils the carbonate is that of calcium, but it may be magnesium carbonate of dolomitic origin. In these cases the gel is a calcium or magnesium alginate.

The preferred polysaccharide is a sodium salt *d*-mannuronic acid. A solution containing as little as 0.1 per cent by weight of this material is effective but for the most satisfactory results the solution should contain 0.5 per cent of the substance by weight or even more if the soil is initially particularly permeable.

Because of the small proportion of the polysaccharide necessary in the solution this method of reducing the permeability of soils is cheap.

The solution may be injected through an injection pipe by means of a pump similar to that commonly used for injecting cement grout or solutions previously used for chemical consolidation of soils.

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Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1962.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.